CA3ONHW Q90
83 G73
~~Copy 2~~

URBAN/MUNICIPAL

POLLUTECH

A GUIDE TO **IMPROVING WATER QUALITY, REDUCING ENERGY REQUIREMENTS, AND IMPROVING PROCESS CONTROL**

FOR THE **WOODWARD AVENUE SEWAGE TREATMENT PLANT**

HAMILTON PUBLIC LIBRARY
JUL 02 1985
GOVERNMENT DOCUMENTS

HAMILTON / WENTWORTH

PREPARED FOR **THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH**

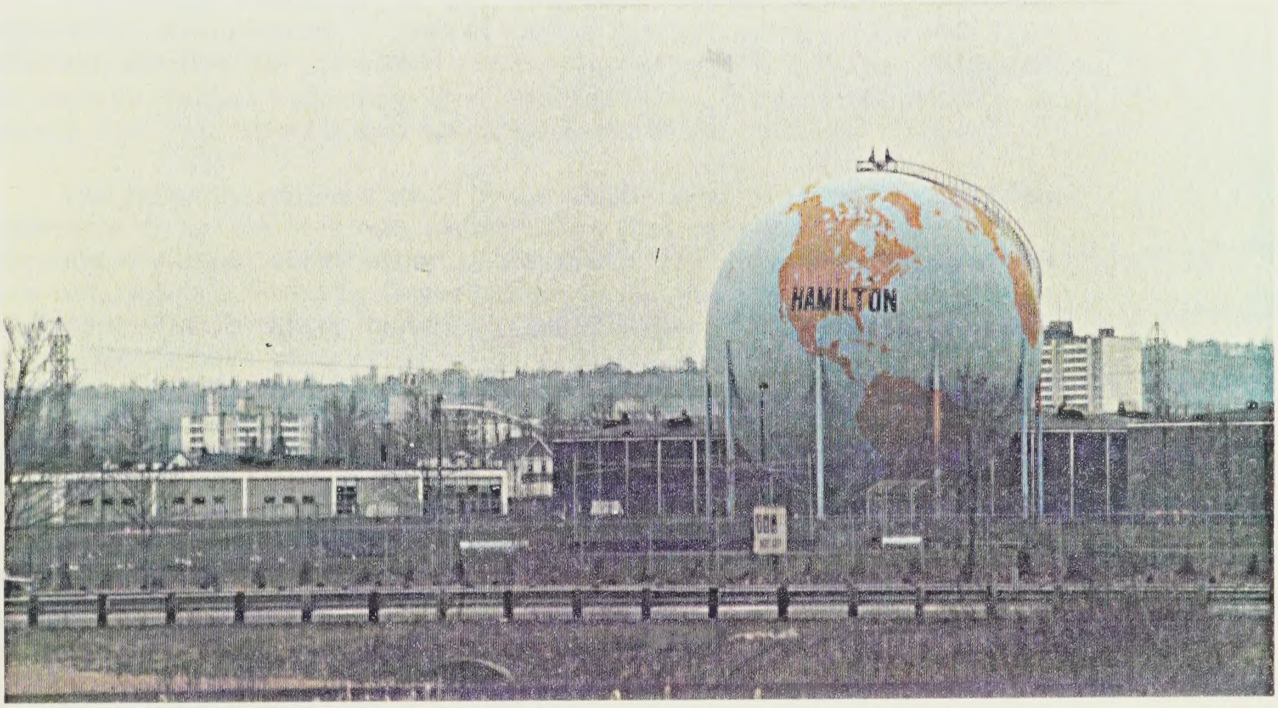
POLLUTECH LIMITED 1090 SPEERS ROAD, OAKVILLE, ONT. L6L 2X4
TELEPHONE: (416) 844-1900

POLLUTECH

A GUIDE TO IMPROVING WATER QUALITY,
REDUCING ENERGY REQUIREMENTS, AND
IMPROVING PROCESS CONTROL

FOR THE WOODWARD AVENUE
SEWAGE TREATMENT PLANT

HAMILTON PUBLIC LIBRARY
JUL 02 1985
GOVERNMENT DOCUMENTS



PREPARED FOR THE REGIONAL MUNICIPALITY OF
HAMILTON-WENTWORTH

POLLUTECH LIMITED 1090 SPEERS ROAD, OAKVILLE, ONT. L6L 2X4
TELEPHONE: (416) 844-1900

Digitized by the Internet Archive
in 2024 with funding from
Hamilton Public Library

https://archive.org/details/guidetoimproving00unse

November 9, 1983

The Regional Municipality of Hamilton-Wentworth,
Department of Engineering,
71 Main Street West,
Hamilton, Ontario,
L8N 3T4

Attention: Mr. J.R.G. Leach,
Commissioner of Engineering

Dear Mr. Leach:

RE: WOODWARD AVENUE SEWAGE TREATMENT PLANT PROCESS OPTIMIZATION REPORT

A thorough evaluation of the Woodward Avenue Sewage Treatment Plant which was initiated in June of 1979 is now complete. Since that time Pollutech Limited has submitted seven progress reports and the findings of two special studies regarding this investigation. Today I am pleased to present this final report which consolidates all of our findings.

The recommendations made in our earlier progress reports have been implemented by the Region's maintenance and operations staff without involving any major construction at the plant. These process modifications have resulted in a dramatic improvement in the Woodward Avenue Sewage Treatment Plant's waste handling capabilities. These effluent quality improvements have been achieved by methods which have actually made substantial reductions in many of the annual operating cost items for the plant. Several process components have been put on standby or shut down which resulted in electrical energy cost savings, and chemical cost savings in excess of $440,000 per year. An additional $460,000 in benefits was achieved through savings in natural gas consumption and reallocation of operation staff positions to the maintenance department. We are indeed pleased to be able to report to you that our fees over the entire four years of this program are substantially less than half of the direct annual cost savings which have been realized by the Region.

We at Pollutech Limited are confident that the Ontario Ministry of Environment effluent requirements for BOD_5 and suspended solids can continue to be met provided that the process control guidelines contained herein continue to be followed.

Yours very truly,

POLLUTECH LIMITED

J.D. Norman, P.Eng., Ph.D.,
President

POLLUTECH LIMITED 1090 SPEERS ROAD, OAKVILLE, ONT. L6L 2X4
TELEPHONE: (416) 844-1900

POLLUTECH

TABLE OF CONTENTS

POLLUTECH

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Process optimization of the Woodward Avenue Sewage Treatment Plant has led to improved plant performance at a lower operating cost. Energy and chemical requirements have been dramatically reduced and the improved process control has allowed for a significant reduction in on-site manpower.

Following a thorough investigation of all of the treatment operations and practices at the Woodward Avenue Sewage Treatment Plant (STP), pilot plant work was initiated on several of the treatment plant components. The favourable results, subsequently demonstrated on the original full-scale secondary treatment plant indicated that the plant had a capability of treating substantially more than its nominal capacity of 60 MGD, while at the same time maintaining acceptable effluent quality.

Improved process control and "fine-tuning" of the numerous treatment operations was accomplished by performing laboratory simulations prior to implementing full-scale modifications. A sequence similar to that identified below was followed for each of the unit operations evaluated:

- Identification of apparent processing "bottlenecks"
- Laboratory simulations conducted to evaluate possible remedial actions
- Pilot plant studies of process adjustments to confirm/refute their full-scale viability
- Full-Scale testing and implementation of process changes

Final Effluent Quality

- On more than one hundred days of the calender year prior to the onset of this study, wastewater entering the plant bypassed one or more treatment operations. Today, bypassing process units is no longer required and is no longer practiced.

- Adherence to the process control procedures recommended will allow an average monthly effluent quality of 15 mg/L suspended solids and 15 mg/L BOD_5 to be maintained, in accordance with the Ontario Ministry of Environment effluent guidelines, even at surge flows exceeding 100 MGD.

- Effluent Suspended Solids concentrations, which averaged 78 mg/L in 1979, have been reduced to a 1982 average of 17 mg/L, representing a net reduction in solids discharged of over 6,500 tons per year.

- Effluent Biochemical Oxygen Demand (BOD_5) was reduced from an average concentration of 44 mg/L in 1979 to less than 12 mg/L in 1982, a total reduction of 3,500 tons per year.

- Total effluent phosphorus, a primary nutrient for algae growth in lakes, has been reduced from an average 1978 level of 2.8 mg/L to 1.1 mg/L in 1982. Correlations suggest that if the influent soluble phosphorus values do not exceed 1.6 mg/L, and that effluent suspended solids are held to 15 mg/L, effluent phosphorus levels should be able to be maintained at or below the 1.0 mg/L requirement without the need for phosphorus removal by physical/chemical treatment.

EFFLUENT DATA

Analysis	Conditions Before Study		Conditions During Study		
	1978	1979	1980	1981	1982
BOD_5(mg/L)	41	44	25	13	11
Suspended Solids (mg/L)	45	78	37	23	17
Total Phosphorus (mg/L)	2.1	2.8	1.6	1.6	1.1
Secondary Treatment Days Bypassed	64	92	8	0	0

Process Control Improvements

- Optimized grit removal, by way of velocity equalization, has shown that at the average daily flow of 60 MGD only two detritor units are required, thus the total average daily capacity of the grit removal facilities is in excess of 120 MGD. Peak flows in excess of 150 MGD can be handled with little disruption to the process. The planned expansion to the detritor units has been indefinitely postponed, and no further additional detritor capacity needs to be considered until the total plant flow exceeds 75 MGD on a regular basis.

- Improved scum removal capabilities have been accomplished by process changes and modification of scum handling equipment by Regional maintenance staff. The existing scum removing facilities were not utilized regularly prior to this study. Now, with minor modifications, this same equipment adequately handles all of the treatment plant scum. Floating scum no longer fouls the biological process, nor is floating scum present in the final effluent, as was commonly the case prior to these modifications.

- Improved primary clarifier operations allow the existing eight clarifiers to readily accommodate the average daily waste flow of 60 MGD. New facilities are no longer required and with minor

modification to the influent channel the existing clarifiers can routinely handle waste flows of over 100 MGD. Capital costs savings associated with the planned primary clarifier expansion, have now been realized.

- By recycling waste activated sludge back to the head end of the plant, settling was improved and the primary clarifier capacity was increased. Implementation of this processing change has resulted in the bypassing of all four dissolved air flotation units. The associated chemical cost in excess of $100,000 annually has been eliminated and the staffing of four man shift complement necessary to operate the flotation units is no longer required.

- Should future growth of the Woodward Avenue STP dictate the need to restart the dissolved air flotation system, then the improved operation and capacity of these flotation units can be realized. With minor mechanical changes, amounting to less than $500 per unit, coupled with process fine-tuning, the capacity of the flotation tanks was increased by over 200 percent, while reducing polymer requirements by up to $100,000 per year.

- Without any construction being required, operational changes have allowed the capacity at the biological treatment system to be more than doubled. Through a reduction in the aeration retention time, significant savings have been

achieved in electrical usage (annual savings over \$200,000) and equipment wear. Concurrent with these savings is the ability to achieve Ontario Ministry of the Environment effluent guidelines which could not be met prior to this study.

- Modifications to the digester operation and mixing equipment by Pollutech , coupled with the repair and cleaning of the anaerobic digesters by the Region, has resulted in an increase in methane production of more than 200 percent. At market value this increased methane production rate represents a potential worth of over \$230,000 per year.

- Optimization of the vacuum filtration operation has allowed for a 40 percent increase in the sludge throughput and cake solids, while reducing polymer consumption to 50 percent of that previously used. The net reduction in polymer alone represents a savings of over \$87,000 per year.

- An optional concept of sludge handling utilizing filtration of raw mixed sludges, rather than digestion followed by filtration, was demonstrated. However, the incineration of raw sludge has been shown to be somewhat problematic and to be successful would require modification to the incinerator control system and increased filter building ventilation.

Cost Savings

The reductions in electrical power and organic polymer consumption, coupled with increased production of digester gas and the reallocation of staffing positions, has resulted in a fiscal benefit package worth over $900,000 per year. A summary of these costs is provided in the following table.

SUMMARY OF COST BENEFITS

COST COMPONENT	DOLLAR VALUE
Electricity(1)	$254,000
Natural Gas(2)	300,000
Polymers(3)	187,000
Manpower(4)	162,000
TOTAL BENEFIT	$903,000

NOTES:

(1) 24 aerators @ 60 HP each taken out of service @ $0.015/kw-hr (16,909,393 kw-hr/year)

(2) net change due to an increase in cake dryness and increased anaerobic digester gas yield:

(a) incineration gas consumption reduction for 200 tons of water per day, where 11,000 BTU per gallon for evaporation, gas at 1,000 BTU per ft^3 and $4 per 1000 ft^3 ($64,000)

(b) gas from digester minimal increase to 6 ft^3 per pound or 98,550,000 ft^3 per year, assuming fuel value only 60 percent of natural gas ($236,000)

(3) Polymer savings of $100,000 per year for flotation and $87,000 per year for vacuum filtration.

(4) Positions reallocated to maintenance department where needed, assuming 9 positions at $18,000 per year inclusive of salaries, overhead, and administration.

STUDY METHODOLOGY

STUDY METHODOLOGY

The process optimization studies which led to the improvement of the Woodward Avenue STP were conducted using laboratory and pilot scale test equipment to define ideal process conditions, followed by an intensive full-scale implementation of the laboratory results. The preliminary laboratory biological aeration tests, as proposed to the Region in June 1979, were successfully completed by October, 1979. Full-scale application of these operating conditions resulted in a significant plant improvement during the latter parts of 1979 and early 1980. By June, 1980, several deficiencies in the remainder of the treatment plant had been identified, and a proposal was made to the Region to expand the "process upgrading" studies to include the grit tanks, primary clarifiers, final clarifiers, dissolved air flotation units, vacuum filters and anaerobic digesters. Throughout 1980 and 1981 detailed laboratory and pilot scale evaluations of these process units were completed. By September 1982 all of the processes had been optimized, and the full-scale plant was operating at these set conditions.

During the course of these studies Pollutech Limited found that the operations personnel were for the most part conscientiously attempting to maintain good treatment operations. Unfortunately, their good efforts were found to be constrained by what were believed to be a number of processing bottlenecks.

In addition, the Regional maintenance staff were facing a mountain of backlogged repairs. An intense remedial maintenance program followed by an improved preventive maintenance program was therefore essential to the successful completion of this project.

The Woodward Avenue STP consists of 11 unit operations which operate together as a treatment system. In conducting fine-tuning studies it is essential to identify the weak points in the system, and therefore modify that particular unit operation to improve the overall system operation. An increase in the size of the unit operation is not always the

solution. More often than not, it is the operating procedures, rather than the unit size, which is the limiting factor.

Rectifying the weak links in the series of unit operations comprising the Woodward Avenue Sewage Treatment Plant was accomplished as follows:

- The unit processes were evaluated in order to identify any equipment failures and/or major operational difficulties.

- Studies were conducted in our laboratory to test various processing adaptations on bench-scale simulations of full-scale operations.

- After a thorough screening of process adaptations, promising ideas were tried on pilot units. These pilot tests provided further information necessary for complete "fine-tuning".

- The modifications to the plant operation, as suggested by the laboratory and pilot scale studies, were implemented on the full-scale plant. Vigilant on-site testing was then conducted to monitor the success of the change.

POLLUTECH

PROCESS OPTIMIZATION

PROCESS OPTIMIZATION

In evaluating the operational procedures at the Woodward Avenue Sewage Treatment Plant each step or unit operation, was carefully studied to determine the cause(s) of the various restrictions. After the process weaknesses were identified, laboratory studies were conducted to determine how these restrictions could be eliminated. The results of favourable experiments were incorporated into the full-scale plant operations making for a more efficient, less costly treatment system.

The results of these various studies and investigations are presented on the following pages. The discussion progresses through the treatment process beginning with the front end of the plant and terminating with the solids handling operations. In addition to the particular process control guidelines, the following achievements were realized:

- A blackboard was set up in the operations room so that sludge blanket levels, digester levels, and pumping rates could be seen at a glance by everyone concerned with the plant operation. In addition, procedures were integrated with the Region's laboratory staff to utilize their computer system to provide streamlined analytical results on a computer printout in order to be more useful for the operating staff.

- Operational staff requirements were re-evaluated in recognition of the revised process control requirements. This resulted in a decrease in operator and operator-helper positions, an increase in Regional maintenance positions, and the addition of more senior level process operation positions.

- The need for a detailed preventive maintenance schedule was demonstrated through a process of working closely together with Regional maintenance and Regional operations staff.

- An increased emphasis was placed on operator training, utilizing "hands-on" procedures which in many cases resulted in an increased awareness of the process by the operating staff. This in turn has contributed to a decrease in the absenteeism rate which had previously been experienced.

A description of the problems identified, work conducted, and optimized conditions for the major process units follows. A separate section on the mechanical bar screens has not been included in the following detailed review as the old bar screens had been previously evaluated by the maintenance staff and were scheduled for replacement. New mechanical bar screens were selected and installed under the direction of Regional engineering staff, independent of the Pollutech study. The incineration process was not evaluated by Pollutech as part of this study.

The process units that were studied and "fine-tuned" by Pollutech were:

- Detritors
- Primary Clarifiers
- Biological Aeration System
- Secondary Clarifiers
- Scum Handling Facilities
- Effluent Chlorination
- Dissolved Air Flotation
- Anaerobic Digesters
- Vacuum Filters

DETRITORS

The detritors, which are mechanically raked grit removal tanks, are responsible for removing all of the inorganic particles (i.e. sand, cinders) having a mesh size of 65 or less (300 um), such that this grit does not pass into the primary clarifiers. If the grit gets through to the rest of the plant it can result in severe plugging of the sludge collection hoppers and cause excessive wear on the raw sludge pumps.

The residence time in the detritors, as determined by the surface area of the units, is critical. The units must remove the troublesome inorganic grit, while at the same time allow organics to pass into the primary clarifiers. Too high of an organic fraction in the grit results in odourous emissions from the grit at the landfill site.

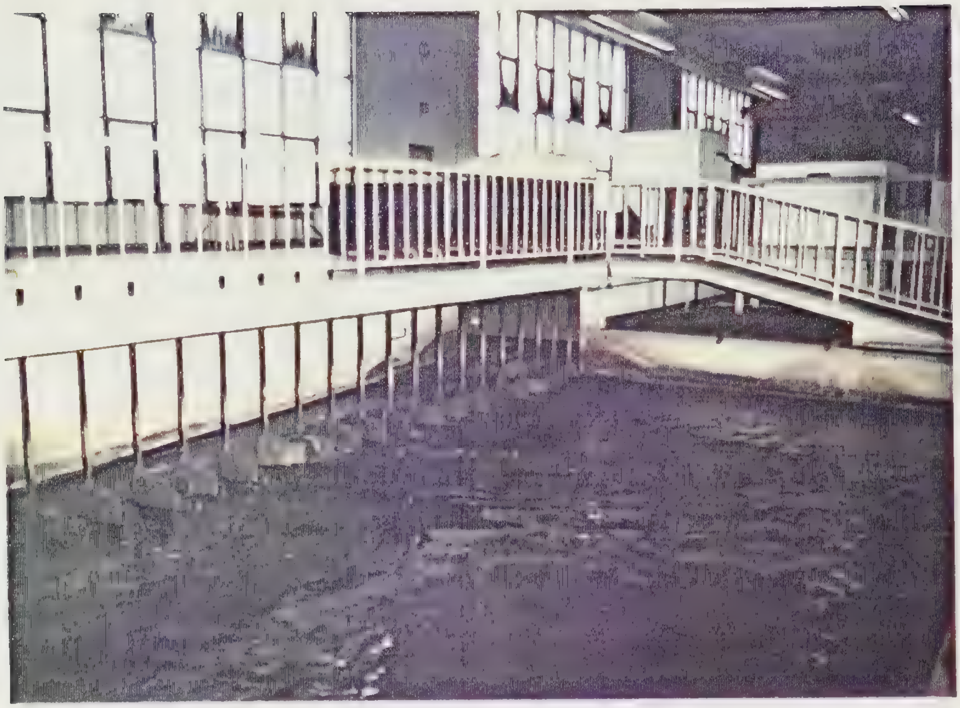
The detritors must be kept in a finely tuned mode to ensure an equal velocity split across the top of each unit. Adequate velocity must be maintained in all channels to eliminate premature settling, which could lead to grit washout under severe storm conditions.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	4	4
Number of units in service at daily average flow (60 MGD)	4	2
Total available process capacity*		
-Average	60 MGD	100 MGD
-Peak	60 MGD	150 MGD
Retention time	2.0 min.	1.0 min.
Loading	8.5 gpm/ft^2	14.1 gpm/ft^2
Operational Efficiency	15 lb./MG	45 lb./MG
Additional input requirements	none	none

*This term refers to the capacity of the process unit , while meeting the treatment objectives. This is not the hydraulic capacity of the unit.

EXISTING DETRITOR UNITS



Major problems identified:

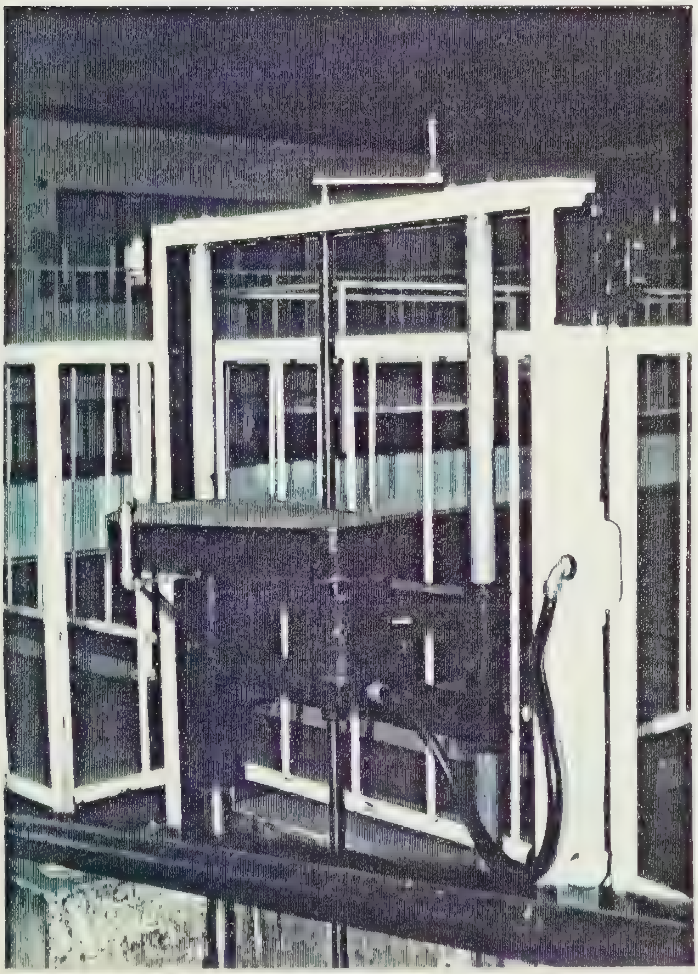
- Excessive amount of grit passing through the units into the primary clarifiers, and from there into the digesters.
- Improperly adjusted flow velocity vanes resulting in severe short circuiting across the top of the units.
- Unequal grit removal experienced between the detritors in service being as low as 3 lb/MG in units #3 and #4, and as high as 53 lb/MG in units #1 and #2.
- Heavy grit deposits in channels feeding the detritor units, and behind the velocity vanes.
- Units #3 and #4 removing mainly fine grit (i.e. mesh 50, 100) and units #1 and #2 removing mainly coarse grit (mesh 5, 14).
- Organic return pump mechanisms plugged with rags, and cleanout difficult and time consuming.
- Large amount of incinerator ash in grit.

Major Corrective Measures Undertaken

- Velocity vanes readjusted under several conditions to eliminate short circuiting.
- Organic return pump removal mechanism installed by maintenance to simplify rag removal.
- Grit conveyance system modified by Regional staff to be more compatible with bar screenings handling.
- Operation modified to match the number of units in service with plant flow to eliminate unit imbalances, grit accumulation and storm grit washout:

0-30 MGD	1 unit	60-75 MGD	3 units
30-60 MGD	2 units	75 plus MGD	4 units

NEW ORGANIC RETURN PUMP FOR EASY CLEANING



Recommended Optimal Operating Conditions:

- Keep velocity vanes adjusted as determined by this study, using a velocity meter for regular checks

- Match the number of units in service to the flow rate as specified to prevent unwanted grit accumulation.

- Install organic return pump cleaning mechanisms on all units, and keep pumps clean.

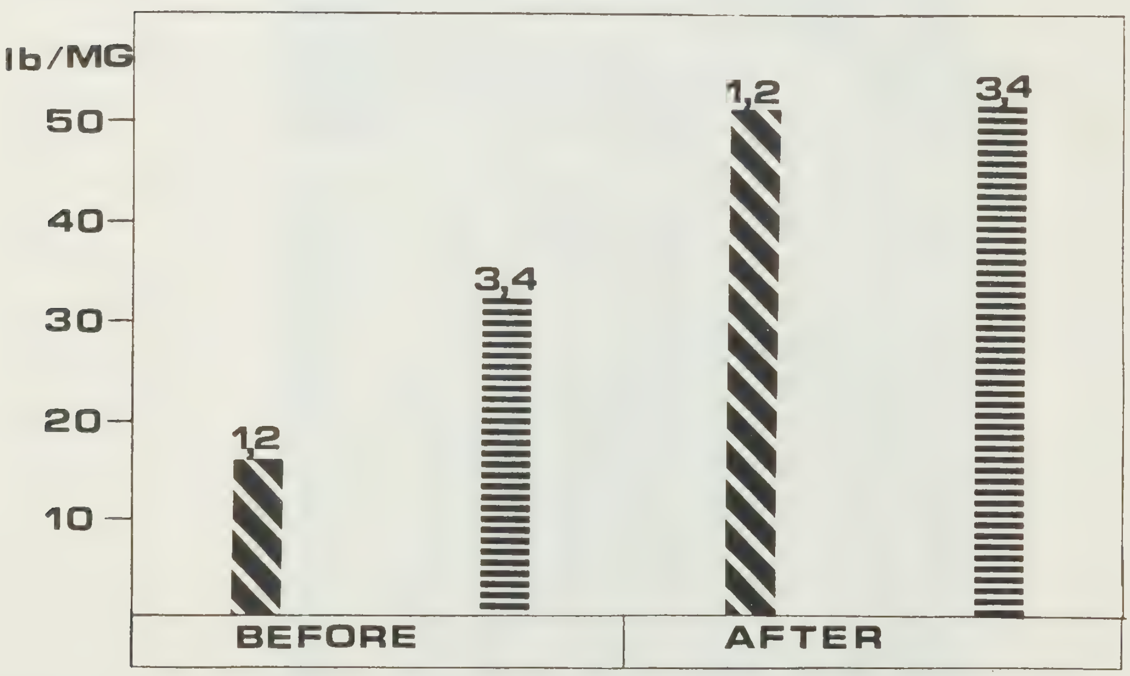
- Conduct frequent (monthly) checks for abnormal deposits of grit in the feed channels and corners of the detritors.

- Maintain proper baffle settings on the organic return pumps to produce grit of low organic content.

- Watch for grit in the primary clarifiers.

- Check grit distribution (mesh size) of each unit at least annually.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING"
GRIT PRODUCTION FROM UNITS



PRIMARY CLARIFIERS

The primary clarifiers are in place to remove settleable organic matter and floating grease which if not removed will have a detrimental effect on the biological treatment system. Primary clarifiers can remove about 30 percent of the influent BOD_5 by removing about 65 percent of the suspended organic matter.

The primary clarifiers must be viewed and operated as a system on their own, for example, what goes in, must come out. If there is 80 tons per day of settleable solids entering the clarifiers, 80 tons must be removed by sludge pumping, or else it will unnecessarily load the biological system.

If solids are left too long on the top (scum) or the bottom (sludge), then they begin to decompose and release foul odours. Sludge will decompose and release odourous hydrogen sulphide, whereas scum will decompose and release putrescible fatty acid odours. Both odours are quite offensive.

The primary clarifiers can be used for primary solids removal alone, or used in conjunction with waste activated sludge removal. In either case, suspended solids removal should exceed 65 percent.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	8	8
Number of units in service at daily average flow (60 MGD)	8	8
Total available process capacity	60 MGD	160 MGD*
Retention time @ nominal capacity	135 min.	50 min.
Loading @ nominal capacity	736 gpd/ft^2	1960 gpd/ft^2
Operational Efficiency - percent solids removal	55% SS Removal	65% SS Removal
Additional input requirements	none	none

* Influent channel needs modification, until changes are made the capacity is limited to 105 MGD.

PRIMARY CLARIFIERS BEFORE FINE-TUNING

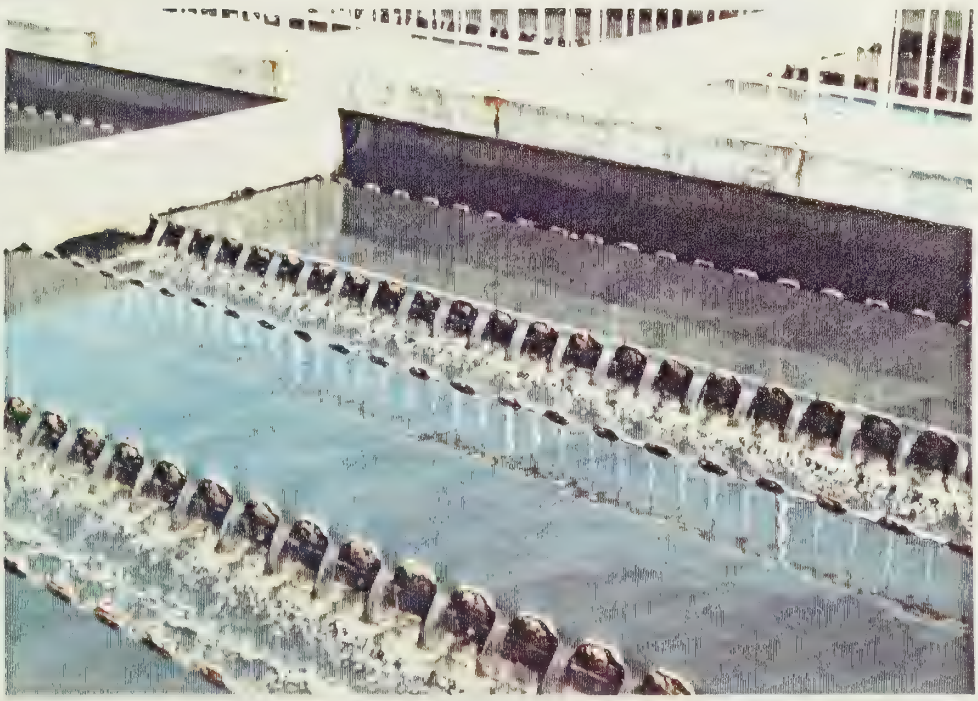
Major problems identified:

- Primary effluent quality was allowed to deteriorate when backups occurred in the solids handling system.
- Apparent hydraulic constraints led to frequent bypassing (over 900 hours in 1978).
- Inadequate scum removal resulted in severe plugging of effluent weirs.
- Solids wash-out interfered with effective operation of the aeration facilities.
- Adverse odour production, particularly during warm weather periods.
- Improper balance between solids input and sludge withdrawal resulting in high sludge blankets.

Major Corrective Measures Undertaken:

- Extensive pilot tube settling tests were conducted to find optimum operating conditions.
- Sludge pumping rates were increased to match the influent solids loading.
- Extensive mechanical repairs were made by Regional staff to upgrade and/or replace worn gears and chains.
- Adjustments were made to equalize influent flow across the various clarifiers using instantaneous flow velocities.
- Scum handling facilities were repaired and improved by Regional staff. Batch handling practices were established, the scum decant system was rebuilt, and process control improvements allowing for year-round scum removal were implemented.
- Waste activated sludge is now returned to the wet well as it has been shown to aid in primary settling without a decrease in hydraulic capacity, and with a savings in sludge thickening costs.

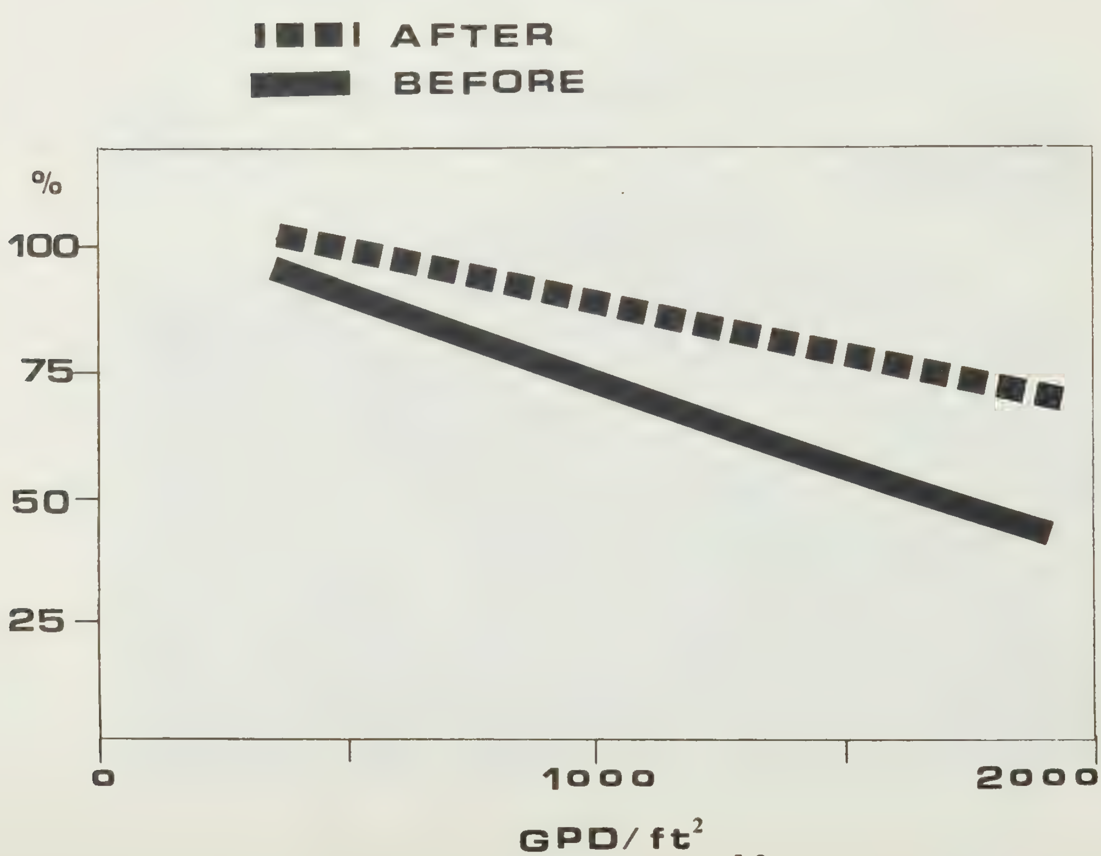
PRIMARY CLARIFIERS AFTER FINE-TUNING



Recommended Optimal Operating Conditions:

- Maintain sludge blanket depth at or below two feet by adjusting sludge pumping rate and rake speed as required.
- Monitor sludge blanket levels on each shift.
- Balance the influent flow rate among the clarifiers in service.
- Practice daily wasting of collected scum.
- If flows exceed 105 MGD, prior to implementation of modifications to the influent channel, the excess effluent from the grit chambers should be bypassed directly to the aeration tanks. This will prevent overtopping of the primary influent channel at the concrete walkway.
- Continue returning waste activated sludge to the wet well to assist in primary clarification of influent wastewater.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING"
CHANGE IN PERCENT SOLIDS REMOVAL
WITH CHANGE IN CLARIFIER LOADING



BIOLOGICAL AERATION SYSTEM

The biological section of the treatment plant is the most sensitive component of the whole system. The biological section can be easily upset either by shocks of quality or quantity of the influent, and an upset of the biological system can often result in a failure of an entire treatment process.

The Biological Unit is a "mass" of living microorganisms maintained under precise conditions (i.e. pH, dissolved oxygen concentration) which are responsible for the conversion of soluble BOD_5 (organic food) into cell mass or carbon dioxide. Carbon dioxide vents to the atmosphere, and cell mass is harvested daily for further treatment. For every pound of BOD_5 treated, approximately one-half pound of cell mass is produced, and the cell mass must be removed as waste biological sludge.

If the biological process is upset in any way, the cells are adversely affected and a poor effluent quality results. Toxicity can result in low food consumption, leaving a high BOD_5 in the effluent. Excess aeration or overloading results in fragmented or "pin floc" which won't settle properly, thus resulting in excess suspended solids in the effluent.

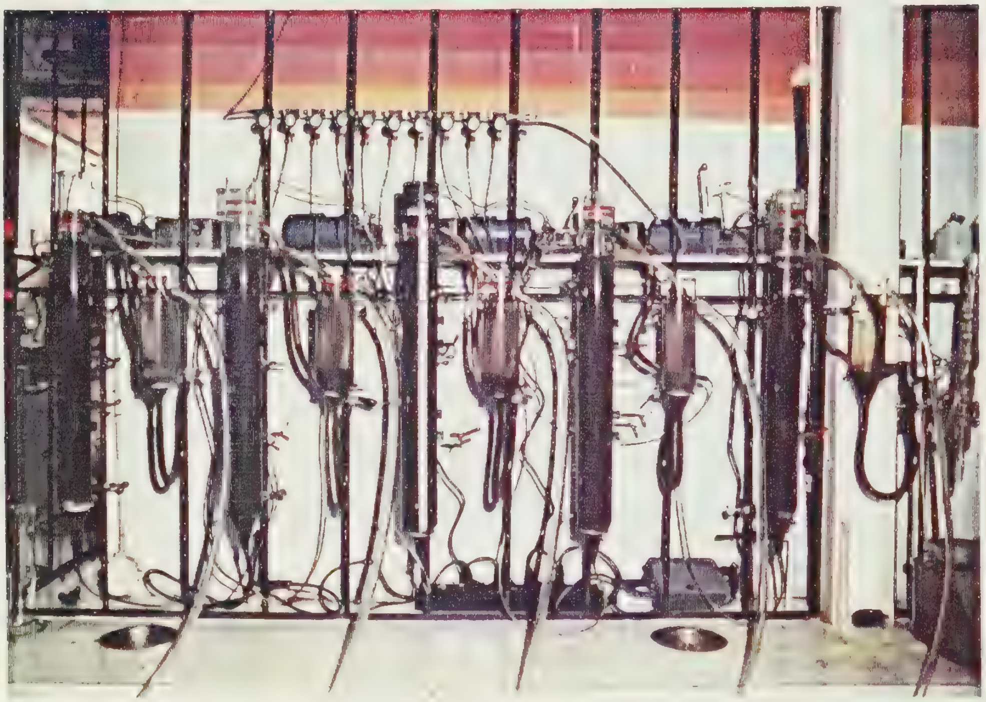
Optimized operation of the biological system also allows for limited control of nutrient levels (i.e. nitrogen and phosphorus) as these nutrients are consumed during the process of cell growth.

NOMINAL OPERATING CAPACITY*

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	48 cells	48 cells
Number of units in service at daily average flow (60 MGD)	48 cells	24 cells
Total available process capacity	50 MGD**	120 MGD
Retention time	6 hours	3 hours
Loading (at BOD_5=150 mg/L)	38 lb BOD_5/1000 ft^3	75 lb BOD_5/1000 ft^3
Operational Efficiency -effluent BOD_5 -aeration bypassing	 42 mg/L 65 days/year	 15 mg/L no bypassing
Additional input requirements	2880 hp/hr	1440 hp/hr

* Does not include 1979 expansion
** Even at 50 MGD suitable effluent not achieved

BIOLOGICAL AERATION TEST UNITS



Major problems identified:

- Unacceptable final effluent quality (BOD_5 and solids)
- Sludge return rates not matched to needs of the system.
- Use of new 30 MGD expansion did not solve effluent problem.
- Biological solids often odourous, dark and unstable and would not settle.
- Fragmented biological floc was resulting in very turbid effluent which resulted in very high effluent BOD_5 and effluent phosphorus
- Numerous grease balls evidenced in aeration tanks.
- In laboratory tests, effluent quality was shown to be highly dependent on growth rate control of biological solids in the aeration tank.

Major Corrective Measures Undertaken:

- Lab and pilot scale studies conducted to determine optimum operating conditions.
- Reduction of tanks (six "cells" each) in service from 8 to 4 at 60 MGD.
- Reduction of 60 H.P. aerators in use from 48 to 24.
- Sludge return facilities calibrated and adjusted to meet process conditions.
- Grease balls manually cleaned from all aeration tanks.
- Improved primary effluent provided a better feed.

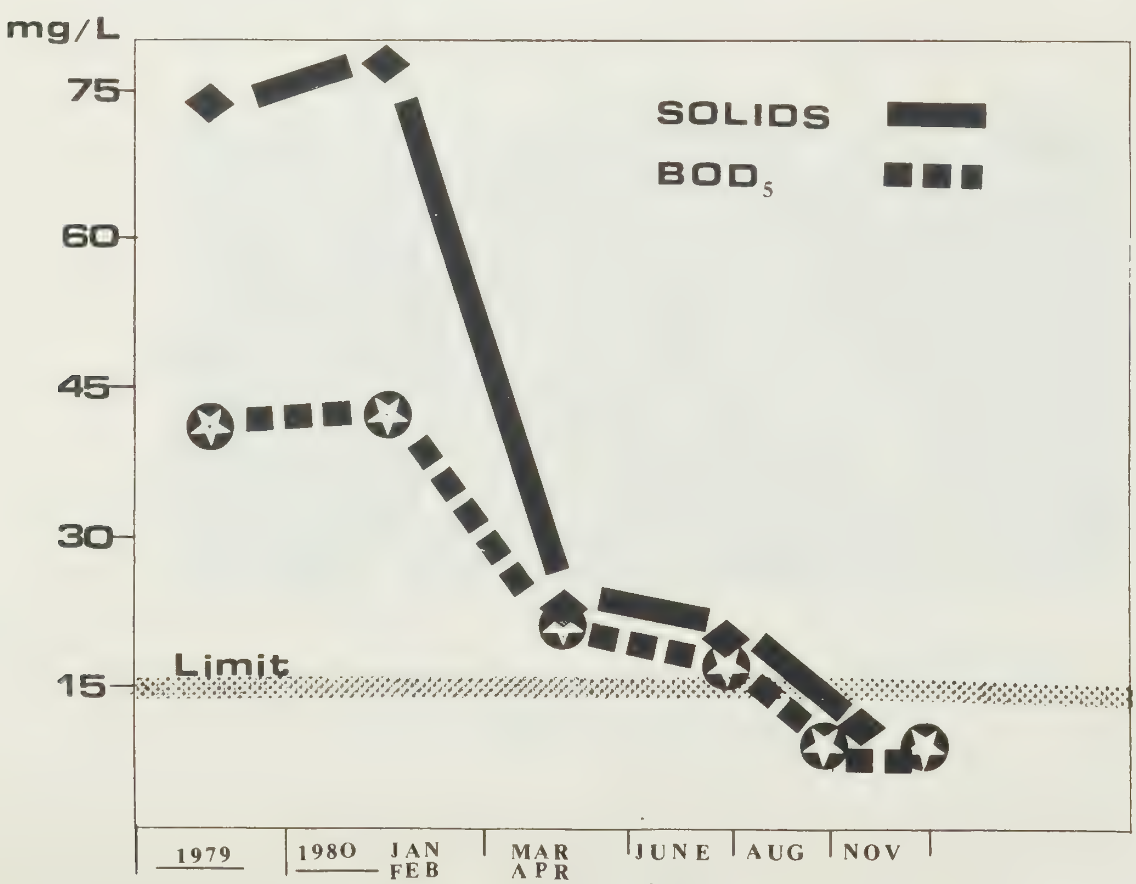
ONLY ONE-HALF OF OLD (NORTH) PLANT AERATION REQUIRED

HALF CLOSED HALF OPERATING

Recommended Optimal Operating Conditions:

- For each 60 MGD of primary effluent to be treated, 7.5 million gallons of aeration tank capacity is required. This is equivalent to four of the six cell aeration tanks in the original plant.
- Maintain the mixed liquor suspended solids level at or about 2,500 mg/L for primary effluent having a BOD less than 150 mg/L.
- Adjust sludge return rates to match the influent hydraulic flow and sludge settling characteristics.
- Reduce oxygen (energy) inputs to prevent over aeration and floc shearing.
- Watch for abrupt changes in the mixed liquor colour and odour.
- Ensure that primary effluent applied to the aeration tank does not contain unnecessary suspended solids which should be contained in the primary clarifier.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING" IMPROVED EFFLUENT QUALITY



SECONDARY CLARIFIERS

The secondary, or final, clarifiers are an integral part of the biological system previously described, as they are responsible for settling and concentrating the mixed liquor from the aeration tanks, thereby producing a "clear" effluent for discharge. The concentrated activated sludge is pumped from the bottom of the clarifier and sent back to the aeration tanks to be fed again. A portion of the activated sludge is also wasted, as the harvested mass of cells previously described.

If the biological reactors produce a biomass which is difficult to settle, there is little the final clarifiers can do to produce a clear effluent. Low BOD removals in the aeration section or formation of an unflocculent biomass will result in failure of the clarifiers unless hydraulic loading is kept well below typical levels.

If the mixed liquor contains a healthy biomass, the final clarifiers can easily produce a final effluent having a BOD_5 of less than 10 mg/L and a Suspended Solids of less than 15 mg/L. Recycle rates of the thickened sludge must be properly controlled, thereby controlling the sludge blankets. Increased capacity can be achieved by using baffling techniques to limit solids carryover by density currents.

NOMINAL OPERATING CAPACITY*

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	8	8
Number of units in service at daily average flow (60 MGD)	8	8
Total available process capacity	60 MGD	120 MGD
Retention time @ nominal capacity	3 hours	1.5 hours
Loading @ nominal capacity	520 gpd/ft^2	1000 gpd/ft^2
Operational Efficiency -Effluent Suspended Solid	45 mg/L	17 mg/L
Additional input requirements	none	baffles**

* Does not include 1979 expansion
**Outside weir raised so first 60 MGD passes over inside weir only.

SOLIDS LOSS OVER EFFLUENT WEIRS

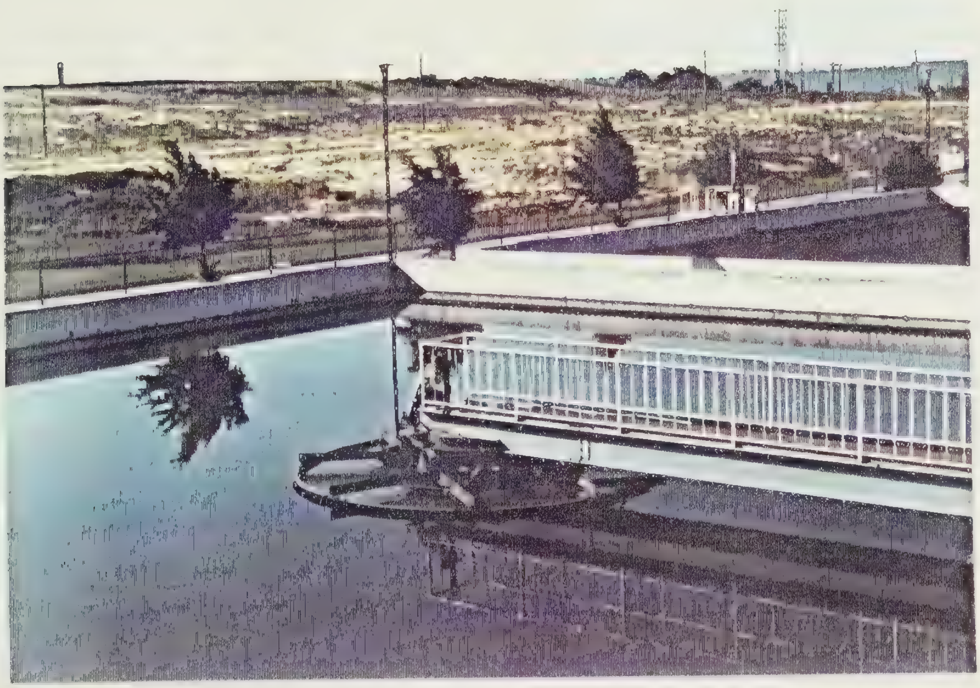
Major problems identified:

- Final effluent quality failed to meet the Ministry of Environment objectives by a wide margin.
- Large plumes of solids being carried over the effluent weirs at several locations.
- Effluent weirs interfered with by grease balls and algae growth.
- Sludge return rates not balanced to the influent flow and solids settling characteristics.
- Sludge blanket levels not controlled.

Major Corrective Measures Undertaken:

- Rapid improvement in sludge settling characteristics by controlling biological solids growth rate.
- Calibration and re-evaluation of sludge return rates and sludge wasting rates.
- Extensive sampling and evaluation of density currents and effect on sludge blankets.
- Full-scale evaluation of baffling within the clarifiers to restrict density current carryover.
- Extensive pilot scale settling tests to determine optimum clarification and sludge thickening conditions.
- Massive clean-up program to remove debris accummulated in the clarifiers over the years.
- Maintenance staff's stepped up program of preventative maintenance.

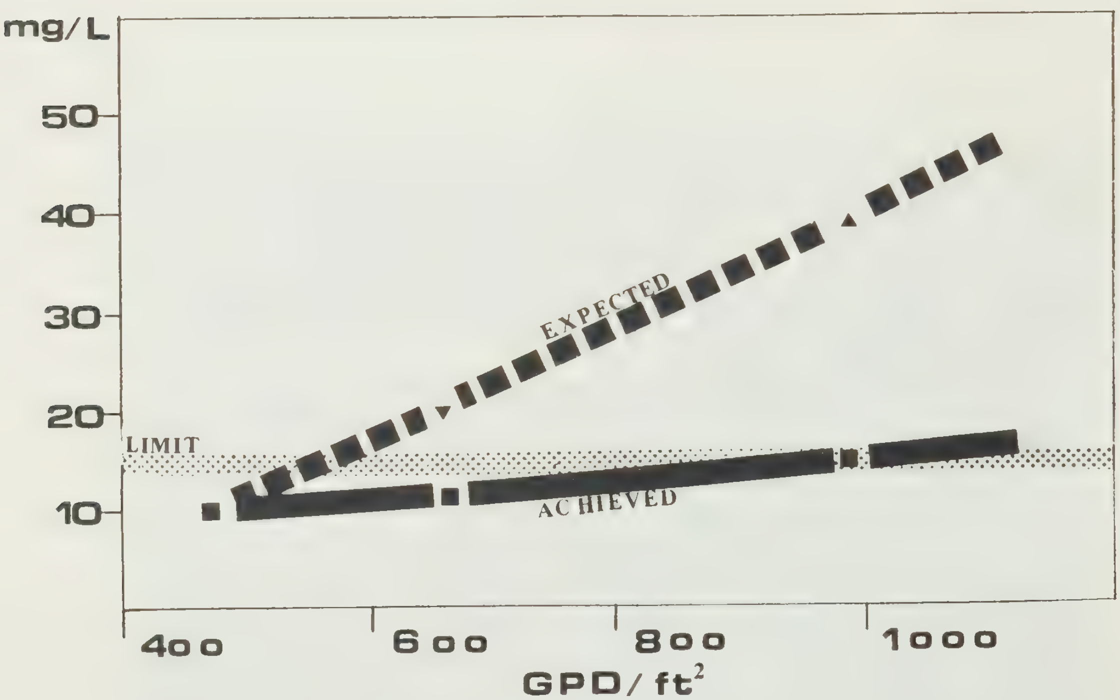
IMPROVED FINAL EFFLUENT AFTER PROCESS "FINE-TUNING"



Recommended Optimal Operating Conditions:

- Maintain suitable quality influent to clarifiers by careful control of the biological system.
- Optimize sludge recycle rates for all changes in influent loading rates and sludge settling characteristics.
- Adjust effluent weirs on the outside rim of all clarifiers such that the first 60 MGD passes over the inside weir only.
- Maintain a thorough housekeeping program to remove debris accummulated on the surface of the clarifiers.
- Balance flows equally between all clarifiers, particularly when one or more clarifiers is out of service.

PLANT PERFORMANCE AFTER "FINE-TUNING"
FINAL EFFLUENT SUSPENDED SOLIDS UNDER HYDRAULIC TEST CONDITIONS



EFFLUENT CHLORINATION

Effluent overflowing the final clarifier weirs is low in BOD_5 and Suspended Solids, but this effluent does contain in excess of 500,000 fecal coliforms per litre of effluent. Effective chlorination can easily reduce the fecal coliform level to less than 100 fecal coliforms per litre, and frequently to non-detectable levels.

Effective chlorination is highly dependent on the quality of the effluent entering the chlorination facilities. An effluent with a BOD_5/Suspended Solids level of 15/15 is likely to have a chlorine demand of 5 mg/L or less. An effluent with BOD_5/SS levels in the 40/40 range would have a chlorine demand in excess of 20 mg/L, and might not be adequately treated with a 30 minute detention time. As the effluent quality deteriorates, the cost of chlorination climbs quickly and the effectiveness drops sharply.

To operate at best conditions requires a clean clarifier effluent and good housekeeping practices to remove any debris in the effluent channel feeding the chlorine contact chamber, or in the chlorine contact chamber itself.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	2	2
Number of units in service at daily average flow (60 MGD)	2	2
Total available process capacity	60 MGD	60 MGD
Retention time @ 60 MGD	30 min.	30 min.
Loading	N/A	N/A
Operational Efficiency	N/A	N/A
Additional input requirements* -Chlorine use	1,691 lb/day	1,291 lb/day

* A full tank car is used each year, regardless of process requirements.

DEBRIS IN CHLORINE CONTACT CHAMBER

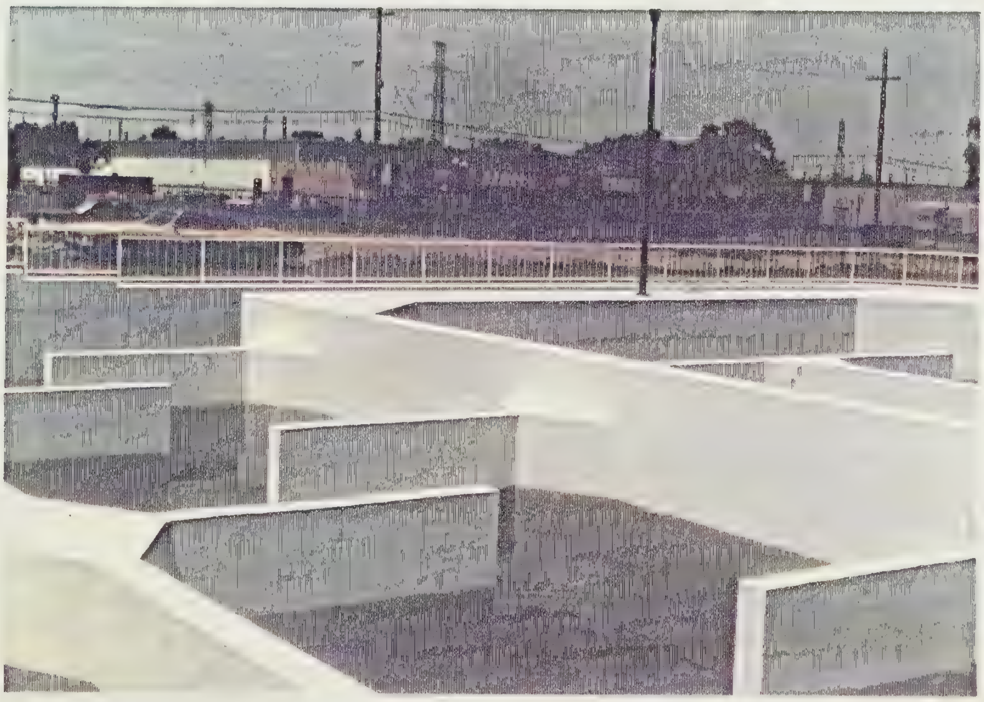
Major problems identified:

- Poor quality of clarifier effluent being fed to chlorination caused high chlorine demand.
- Due to long periods of poor effluent quality there was a build-up of solids and debris in the effluent channel feeding the chlorine contact chamber which caused further effluent quality deterioration.
- As a result of bypassing, the chlorine contact chamber contained significant deposits of grit and debris which severely reduced the effective chlorination.
- Chlorine consumption was excessive.
- Bacterial kill was hampered.

Major Corrective Measures Undertaken:

- Problem of high chlorine demand as a result of poor effluent quality was documented.
- Significant deposits of sludge and debris in the effluent channel were identified.
- Grit and debris in the chlorine contact chamber were located and removed by a contractor.
- Chlorine contact chamber feed gates were repaired by an outside contractor.
- Chlorine contact chamber was sand-blasted and repainted by an outside contractor.
- Chlorine supply was reduced to match reduced chlorine demand.

RENOVATED CHLORINATION FACILITIES



Recommended Optimal Operating Conditions

- Maintain a suitable clarifier effluent quality in terms of chlorine demand.
- Ensure that the effluent channel and the chlorine contact chamber are kept free of sludge and grit deposits at all times.
- Monitor the chlorine demand of the final effluent on a regular basis and watch for irregularities.
- Maintain a residual chlorine level of 0.5 mg/L during operating periods.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING" CHLORINE CONSUMPTION*

Year	Days of Chlorination	lb/year	lb/day	lb/MG
1978	156	230,870	1480	28.1
1979	167	264,249	1582	28.6
1980	164	330,195	2013	37.2
1981	176	220,000	1250	21.5
1982	165	220,000	1333	22.4

* A full tank car of chlorine is used each year

DISSOLVED AIR FLOTATION

Waste biological sludge can be removed from the system by discharge to the primary clarifiers, and thereafter to digestion, or by separate dissolved air flotation thickening of the waste biological sludge, followed by digestion. In either case the purpose is to send a concentrated waste biological sludge to digestion. Currently the dissolved air flotation method has been set aside in favour of waste sludge removal with the raw primary sludge.

When in operation, the flotation units rely on a mechanical process of attaching minute air bubbles to the sludge particles, causing the sludge to float to the surface of the unit, where it is skimmed off in a concentrated form. Having the right amount of air is critical to the successful operation of the flotation units. The weight of air per unit weight of solids treated is set by controlling the pressure of the air dissolving tank, the amount of air saturated recycle returned to the front of the process, and the feed rate of solids into the flotation tank. The ability of the waste sludge particles to separate from the water, and float to the surface, is further enhanced by the addition of a small amount of organic polymer.

Successful operation of the dissolved air flotation system is highly dependent on the air dissolving (saturation) component. This was found to be totally unsuitable on the existing units and thus the flotation system had little chance of successful operation, until such time as this mechanical "weak link" was adjusted.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	4	4
Number of units in service at daily average flow (60 MGD)	4	3*
Total available process capacity	13 tons/day	38 tons/day
Retention time	N/A	N/A
Loading	0.7 $lb/ft^2hr.$**	2 $lb/ft^2/hr.$***
Operational Efficiency	Frequent Failures	Stable Operation
Additional input requirements -Polymer addition	10 lb/ton	3 lb/ton

* When in Service
** Based on 5,665,130 lb/year, 19.5 hours/day, 106 days out of service
*** Full-scale test results

LABORATORY SCALE FLOTATION UNIT

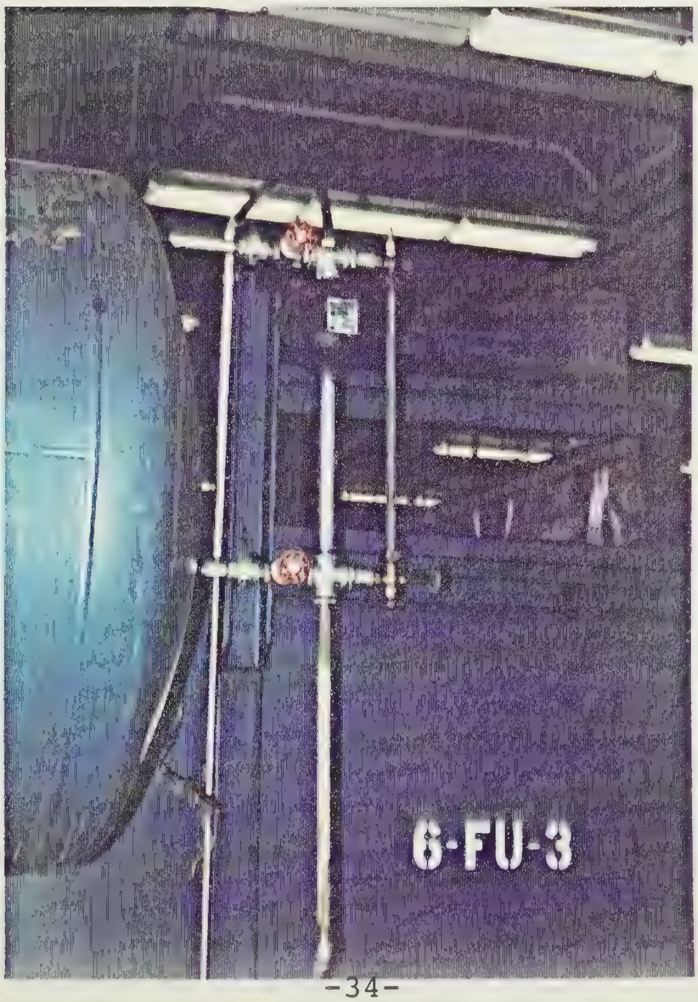
Major problems identified:

- Recurring failure of the dissolved air flotation system as a results of the failure in the air dissolving equipment.
- Erratic loading of the units due to the routine overloading of one or more flotation units
- Overdosing of organic polymers in a attempt to maintain operation, despite the mechanical problems.
- General lack of understanding of the flotation process by the plant operators.
- Use of "quick" jar tests to determine operating conditions were relied on heavily but utilized improperly.
- Little or no attention was paid to the effect of scraper control on the removal of sludge from the top of the flotation unit.
- Too much emphasis placed on subnatant suspended solids concentration.

Major Corrective Measures Undertaken:

- Modified liquid level control system installed on two units to demonstrate improvement.
- Detailed process studies on laboratory units conducted to optimize the air/solids ratio.
- Laboratory screening conducted on polymer types and doses to minimize chemical needs.
- Full-scale "fine-tuning" tests were carried out within the limits of the laboratory screening trials.
- Correct operating procedures for feeding rate, recycle rate, polymer dose, and skimmer speed were identified and implemented.
- Operators were given "hands-on" assistance in the operation and understanding of the process.

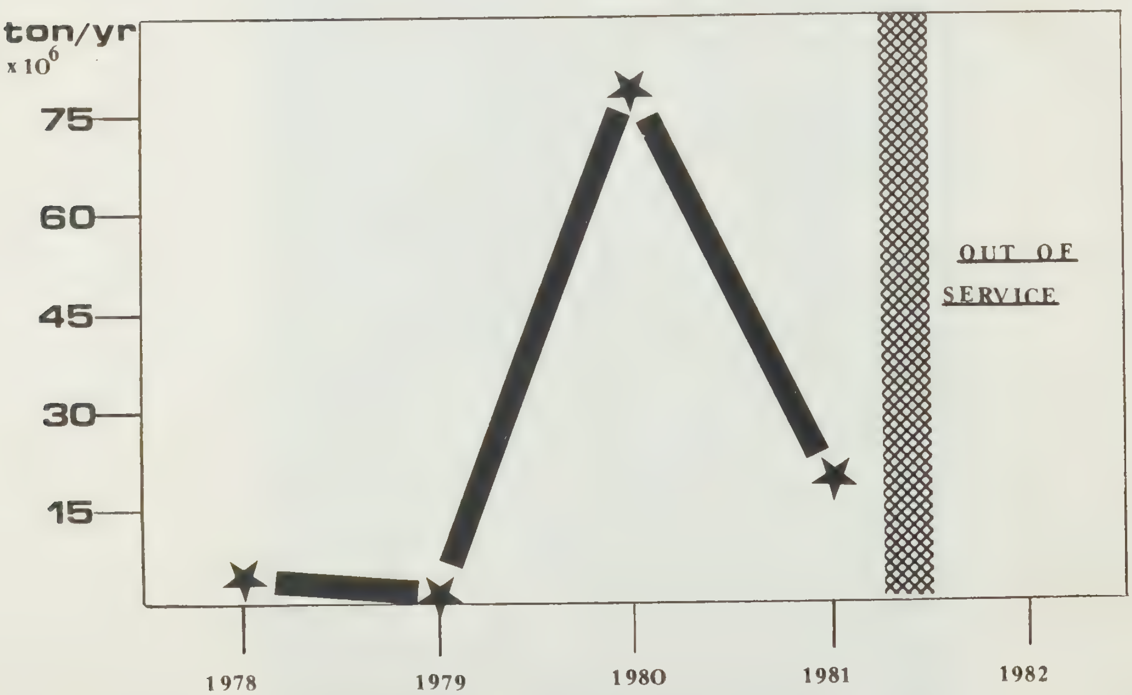
MODIFIED CONTROLS ON FLOTATION SYSTEM



Recommended Optimal Operating Conditions:

- Maintain a feed waste activated sludge concentration of approximately 0.8 to 1.0 percent solids.
- Maintain a hydraulic loading rate of 150 to 170 gallons per minute.
- Maintain a recycle rate of 275 percent to maximize float solids and minimize polymer consumption.
- Maintain a polymer dose of not more than 3 pounds per ton of solids processed.
- Utilize routine monitoring of the flotation mixed influent rise rate to control the process operation.
- Pay more attention to "tons processed" and "polymer saved", and less attention to subnatant effluent quality.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING" SLUDGE PROCESSED BY FLOTATION



ANAEROBIC DIGESTERS

The anaerobic digesters fulfill two major roles of this plant, namely (1) they are a "sink" for the storage of sludges prior to filtration, and (2) they allow for conversion of the organic matter to a "storable" energy form as methane gas. At many other installations the anaerobic digesters are primarily a form of sludge stabilization. Stabilization is not required at this plant, as the sludge is incinerated, not landspread.

In order to operate properly the anaerobic digesters must be treated like the sensitive biological reactors they are. The anaerobic digesters are even more sensitive than the biological aeration system, as anaerobic digestion utilizes a two-stage, rate limiting biological reaction. Organic solids are first converted to organic acids (which is easy) then the acids are converted to methane (which is often troublesome). The biological reaction is often disturbed before methane can form, thus the digester goes sour (i.e. it becomes too acidic). Temperature, mixing and loading rates determine whether suitable process conditions are available.

The primary anaerobic digester is the main biological reactor. The secondary digester acts as a clarifier/thickener to produce a low solids supernatant for discharge back to the treatment plant, and a concentrated sludge for pumping to the vacuum filters.

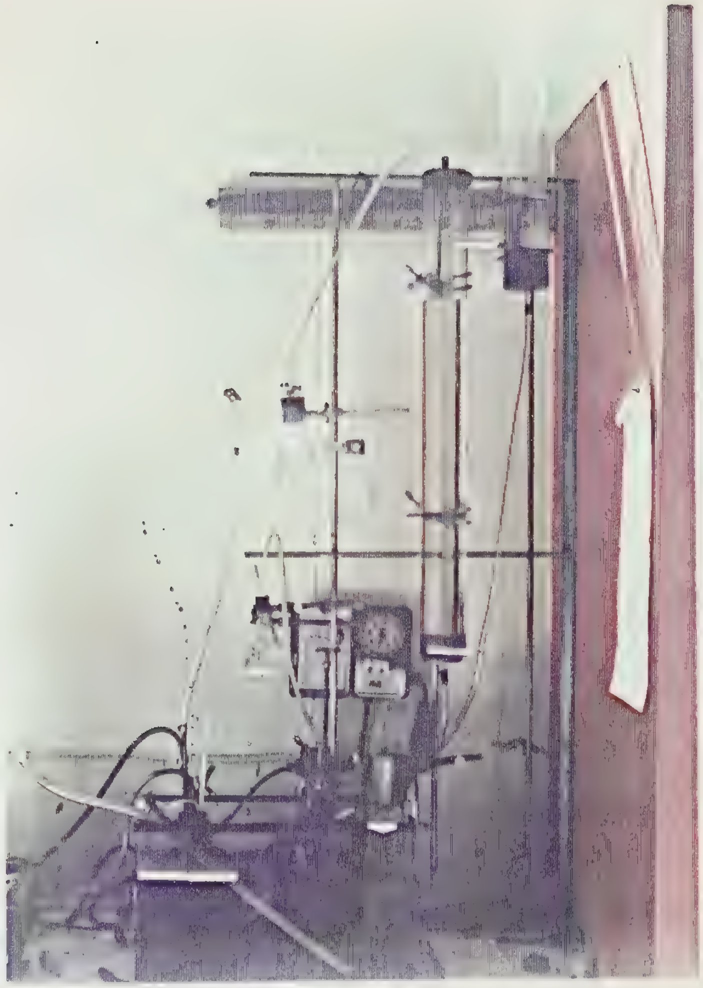
NOMINAL OPERATING CAPACITY*

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	8	8
Number of units in service at daily average flow (60 MGD)	8	4**
Total available process capacity -Solid Loading Rate (dry tons)	40 tons/day	150 tons/day
Retention time -in primary digester	40 days	10-15 days
Loading -to primary digester	0.05 lb vss/ft^3/day	0.1 lb vss/ft^3/day
Operational Efficiency -gas production @ 60MGD	200,000 ft^3/day	1,150,000 ft^3/day
Additional input requirements	none	none

*Full scale test results to receive further confirmation after all mechanical repairs completed.

**As per Regional plan for routine maintenance etc.

LABORATORY SCALE
ANAEROBIC DIGESTER



Major problems identified:

- Mechanical repairs required to upgrade several of the digesters, including roof leaks and worn out mixers.

- Most of the digesters contained significant deposits of grit and/or non-mixable debris that severely restricted the available digester capacity.

- The digesters were not producing a consistently thickened underflow of digested sludge for vacuum filtration.

- Digester supernating was being practiced to produce space in the digesters with little or no attention to the quality of supernatant discharged.

- There was no available measurement for gas production, as all flow meters were inoperative.

- Records of sludge pumped to the digesters were not in agreement with the amount of raw primary sludge and waste activated sludge produced (i.e. metering and record keeping problems).

Major Corrective Measures Undertaken:

- Extensive laboratory digester studies were carried out to confirm the suitability of the process, determine gas production rates and evaluate supernatant quality.

- Full-scale evaluation of the mixing capabilities of each unit was determined.

- Maintenance staff undertook to repair all sludge pumps and mixers, and clear all lines.

- Regional staff engaged a contractor to clean out all of the digesters.

- Pumping of sludge to the digesters became the subject of thorough monitoring and control.

- Supernating procedures were modified to improve supernatant quality and regulate supernating times.

- Regional operations staff adopted a program of long-term routine cleaning maintenance.

FULL-SCALE DIGESTER CLEANOUT

Recommended Optimal Operating Conditions:

- Maintain a near constant feed rate to the digesters from the primary clarifier (and flotation units if in service).

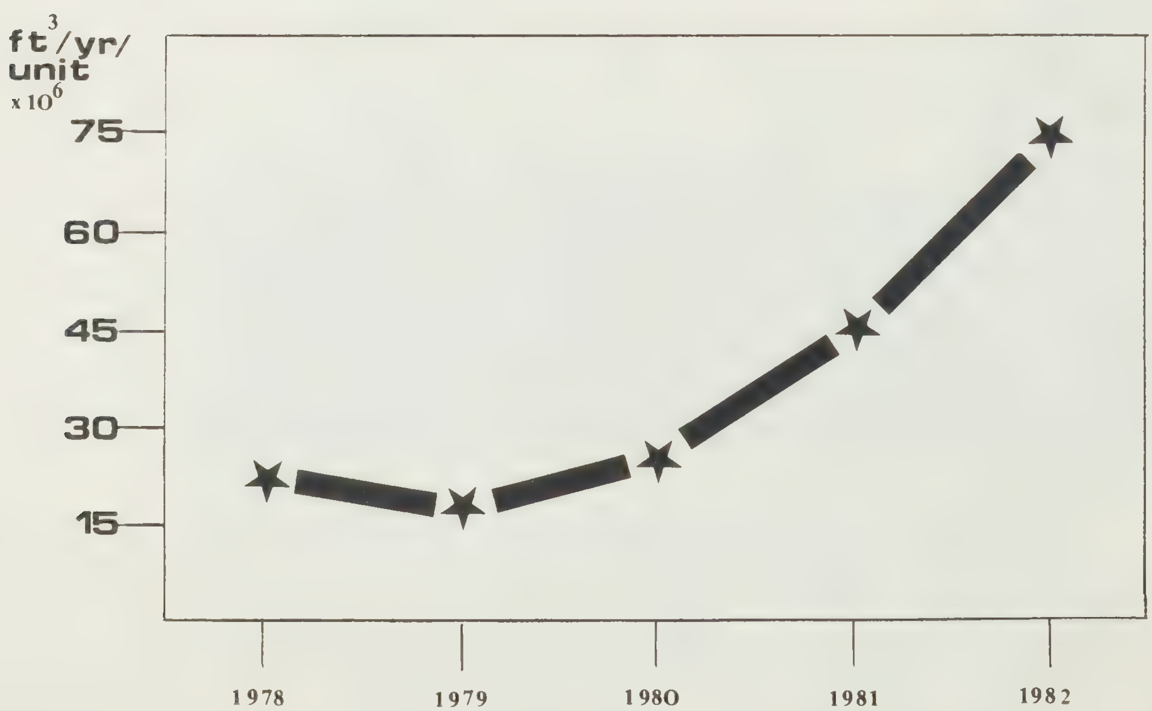
- Discharge supernatant from the secondary digester on a routine and well controlled basis, checking regularly for the occurrence of high solids in the supernatant.

- Check the mixing efficiency of the mechanical mixers, or gas guns, regularly to ensure the maximum "effective digester volume" is being utilized.

- Monitor gas production, acids/alkalinity ratio, sulphide levels and temperature daily, and act promptly when abrupt changes are noted.

- Monitor the effectiveness of the increased digester loading rates.

PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING"
SLUDGE PROCESSED BY DIGESTION
(methane production)



VACUUM FILTERS

Sludge from the wastewater treatment process (primary or waste activated; raw or digested) must be dewatered prior to incineration so as to reduce fuel demand for water evaporation and increase throughput of the incinerators. The two incinerators are currently restricted to a loading of 10 wet tons per hour, which means to accept the 80 tons/day dry solids produced, the filter cake must be at least 15 percent solids (510 wet tons/day). Increasing the cake solids to 20 percent solids reduces the total loading to 320 wet tons/day, which allows for filter operation only 70 percent of the time, leaving 30 percent of the time for filter cleaning and repairs.

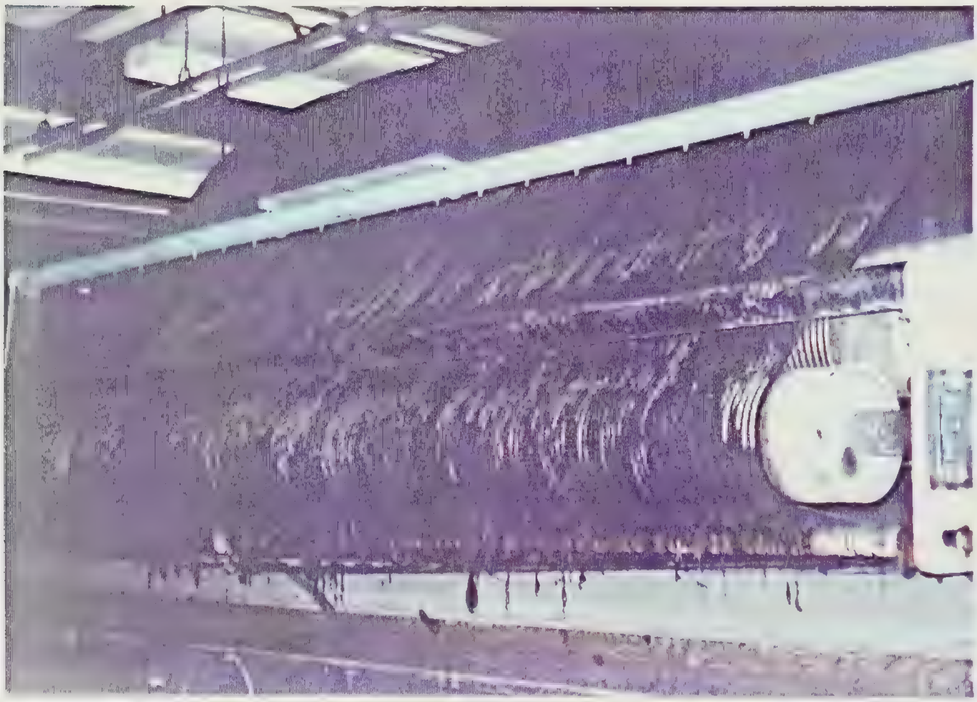
Improving filter yield (cake solids and solid recovery) can be attained by maximizing the solids input to the filter, optimizing polymer type and dose, and "fine-tuning" the filter operation (cycle time, loading rates, etc.) The filters operate best when the sludge cake has a fibrous nature, thus sludge containing raw primary sludge filters the best. As the percentage of waste activated sludge increases, the efficiency of the filters drops off. Similarly, the more a sludge is digested, the more difficult it is to filter.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	4	4
Number of units in service at daily average flow (60 MGD)	4	4
Total available process capacity	55 dry tons/day*	80 dry tons/day
Retention time	N/A	N/A
Loading	2.3 lb/ft^2/hr	3.3 lb/ft^2/hr
Operational Efficiency	80% Solids Capture 8-12% Cake Solids	95% Solids Capture 14-18% cake solid
Additional input requirements - Polymer	6 lb./ton	3 lb./ton

* Units could not keep up with production.

"WORST-CASE" FILTER OPERATION BEFORE "FINE-TUNING"



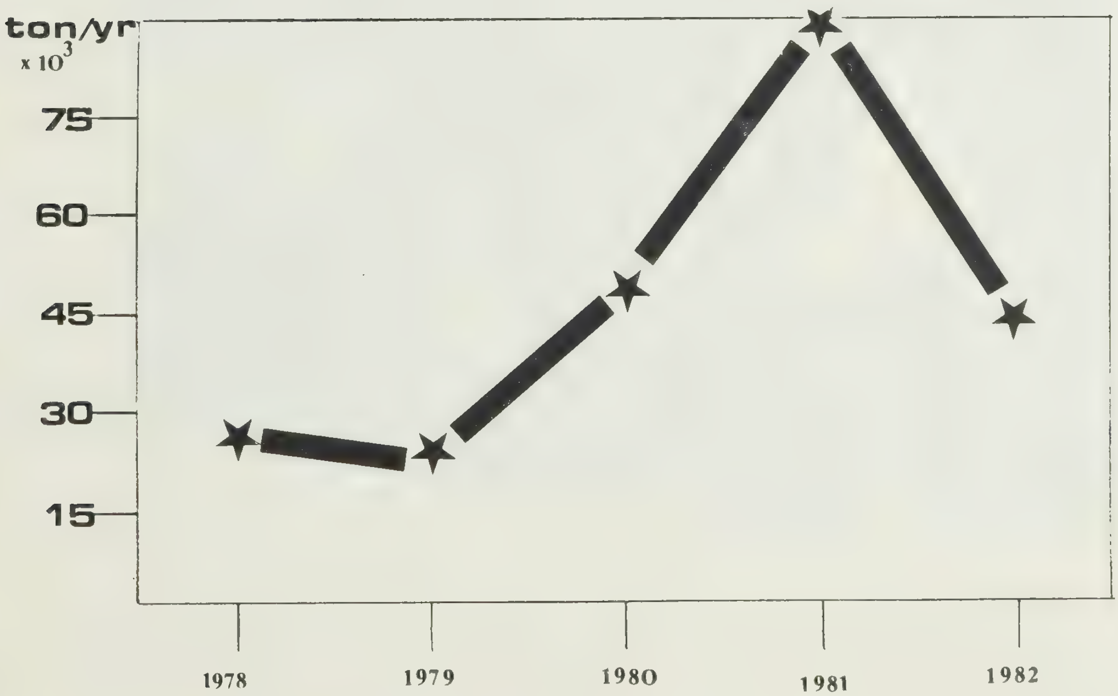
Major problems identified:

- Filters were generally in a poor state of mechanical repair.
- Operations staff were not fully aware of proper operating procedures, and how process changes affected the filter operation.
- The polymer mixing system was inadequate and severely hampered effective flocculation.
- The type of sludge selected for filtration was of poor quality, thus making proper filtration nearly impossible.
- The polymer was often overdosed, while the unit was being underfed, which is the worst possible combination.
- The resultant filter cake was wet, plugged the coils easily, and covered only a fraction of the available filter surface area.
- Filters had to be shut down whenever the incinerator was out of service due to the absence of "storage" space.

Recommended Optimal Operating Conditions:

- Maintain a feed rate to the filters of at least 50 gpm, at or about 6 percent solids.
- Match the drum speed of the filter to the feed rate (e.g. 12 RPH at 65 gpm) to maintain a constant sludge level in the vat.
- Operate the filters with a polymer dose of not more than 5 lb/ton, as an increase in polymer decreases the efficiency of the units.
- Check the degree of flocculation of the sludge after mixing in the conditioning tank on a regular and frequent basis.
- Maintain a sludge level in the vat such that the level is 10 to 12 inches below the top of the vat, to ensure proper drum submergence.
- Watch all of the operating conditions very carefully and make adjustments as necessary to match changes in sludge loading rates and changes in sludge quality.

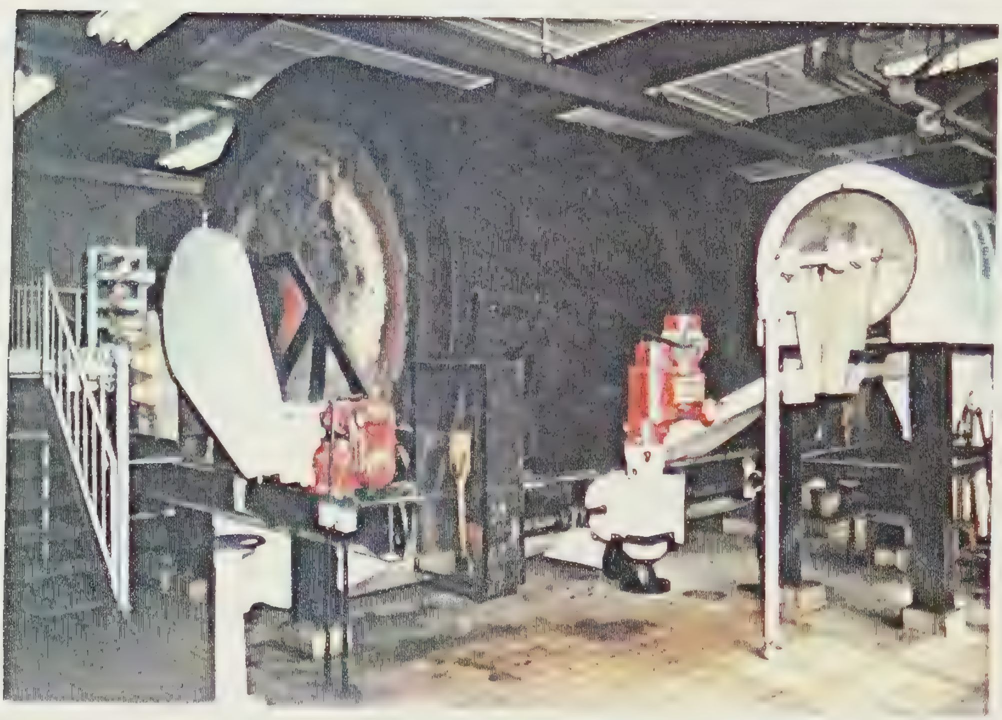
PLANT PERFORMANCE BEFORE AND AFTER "FINE-TUNING"
SLUDGE PROCESSED BY FILTRATION



Major Corrective Measures Undertaken

- Detailed laboratory tests were conducted to optimize polymer type, polymer dose, dilution water feed rates, cycle times and loading rates.
- Maintenance staff were directed towards an upgrading of the existing filters, including a more regular preventive maintenance program.
- Full-scale trials were conducted to demonstrate proper techniques for starting the filters, maintaining a good sludge cake and optimizing the polymer dose.
- A by-pass system was installed by maintenance staff to allow for operation of the vacuum filters, even when the incinerators were out of service

IMPROVED FILTER OPERATION AFTER "FINE-TUNING"



SCUM HANDLING FACILITIES

Floating oils and greases which surface on the primary clarifiers are scraped off into a scum hopper near the effluent weirs of the primary clarifiers. After collection in these scum hoppers, the scum is "flushed" into a pit, and from there is pumped 700 feet to a scum decant tank in the vacuum filter building. Once collected and concentrated at the scum tank, the scum may be directed either to incineration or landfill.

Although not one of the most pleasant tasks, the labour intensive removal of scum is an integral part of the sewage treatment operation. Failure to provide adequate scum removal results in fouling of both the primary clarifier and secondary clarifier weirs, and the build-up of massive numbers of "grease balls" within the aeration system. The amount of manpower needed to remove the grease in one central location is far less than that required for remedial grease removal once the grease has broken through the system.

NOMINAL OPERATING CAPACITY

	Conditions Before Study	Conditions After "Fine-Tuning"
Number of units	1	1
Number of units in service at daily average flow (60 MGD)	0	1
Total available process capacity	out of service	160 MGD
Retention time (Decant Tank)	out of service	*
loading	out of service	accommodates all scum
Operational Efficiency	out of service	accommodates all scum
Additional input requirements	out of service	N/A

*Retention time varies with operator and daily load (variable). Unit is 750 ft^3 and sludge pumps at 0.9 gal/stroke.

SCUM IN PRIMARY CLARIFIERS AT START OF STUDY

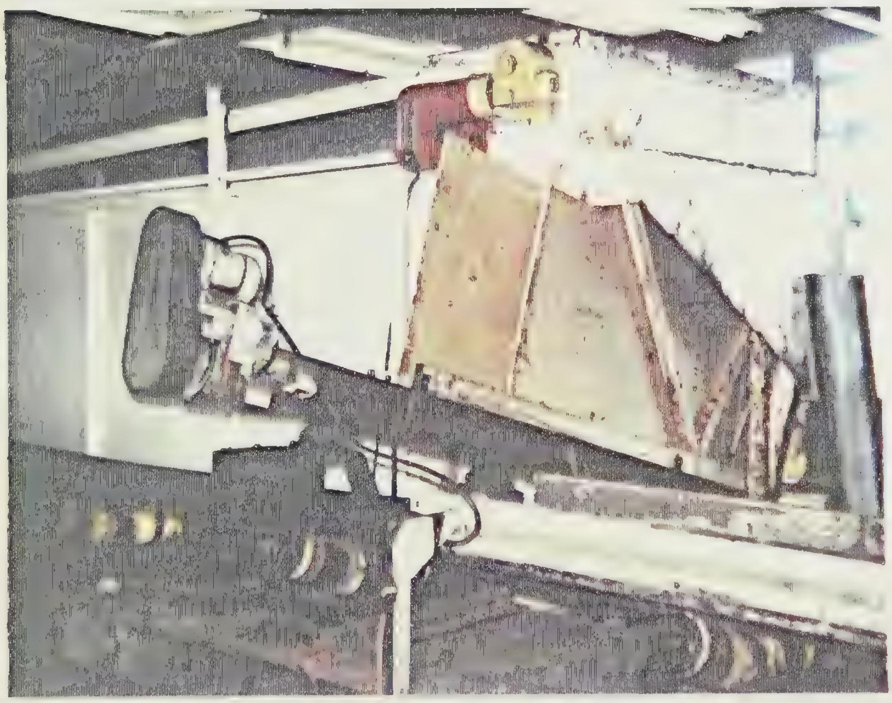
Major problems identified:

- Excessive build-up of grease balls and scum in the aeration tanks and final clarifiers.
- Severe backlog of scum in the scum troughs of the primary clarifiers.
- The scum transfer line from the scum pits to the scum decant tank was plugged, and had been so for the past several years.
- The scum scrapers, effluent washers and pits were in drastic need of maintenance.
- The scum decant tank in the vacuum filter building was not equipped with adequate scum scrapers or an adequate scum transfer system.

Major Corrective Measures Undertaken:

- Backlog of scum was cleared up by an intensive manual operation spearheaded by Pollutech staff.
- A regular routine of scum removal and scum pumping was developed.
- A demonstration of an alternative scum transfer technique was implemented on the full-scale system using a mechanical auger rather than the existing pumps.
- Regional staff cleaned out the plugged scum transfer line.
- Regional maintenance staff implemented an intensive repair program for the primary clarifier scum collectors.
- Regional maintenance staff re-built the existing scum decant tank including installation of a heavy duty scraper system and a new scum conveyor system.

<u>TEST AUGER TO EVALUATE REBUILDING SCUM COLLECTION SYSTEM</u>



Recommended Optimal Operating Conditions:

- Maintain a rigorous program of scum removal at the primary clarifiers.

- Remove any grease balls from the aeration tanks which form from grease "breakthrough".

- Routinely remove floating scum, greaseballs and other objects from the final clarifiers.

- Follow proper pumping/flushing procedures in transferring scum to the scum decant tank to minimize chances of plugging the scum transfer line.

POLLUTECH

STATUS REVIEW

STATUS REVIEW

The total Woodward Avenue Sewage Treatment Plant contains 10 individual process units directly involved in the treatment of the liquid stream and subsequent handling of the solid residues. As there are several critical operational controls in any one unit process, we estimate there are as many as 30 potential weak links in the treatment chain. A failure of any one link can affect not only the individual process unit, but the whole treatment process.

To assist in the understanding of the treatment plant, and how all the unit processes tie in together, we have constructed a simplified process schematic. On this schematic we have indicated the nature and location of critical process control parameters and the status of each unit process by way of the following numerical codes: (i.e. 1)

1 Mechanical organic return pump cleanout mechanism not yet installed

2 Restriction of influent feed channel restricts flow to 105 MGD

3 Outside effluent wier to be raised or baffling installed as on test unit

4 Gas firing mechanism to be modified to match No. 3 primary digester

5 Upgrading of polymer mixing system

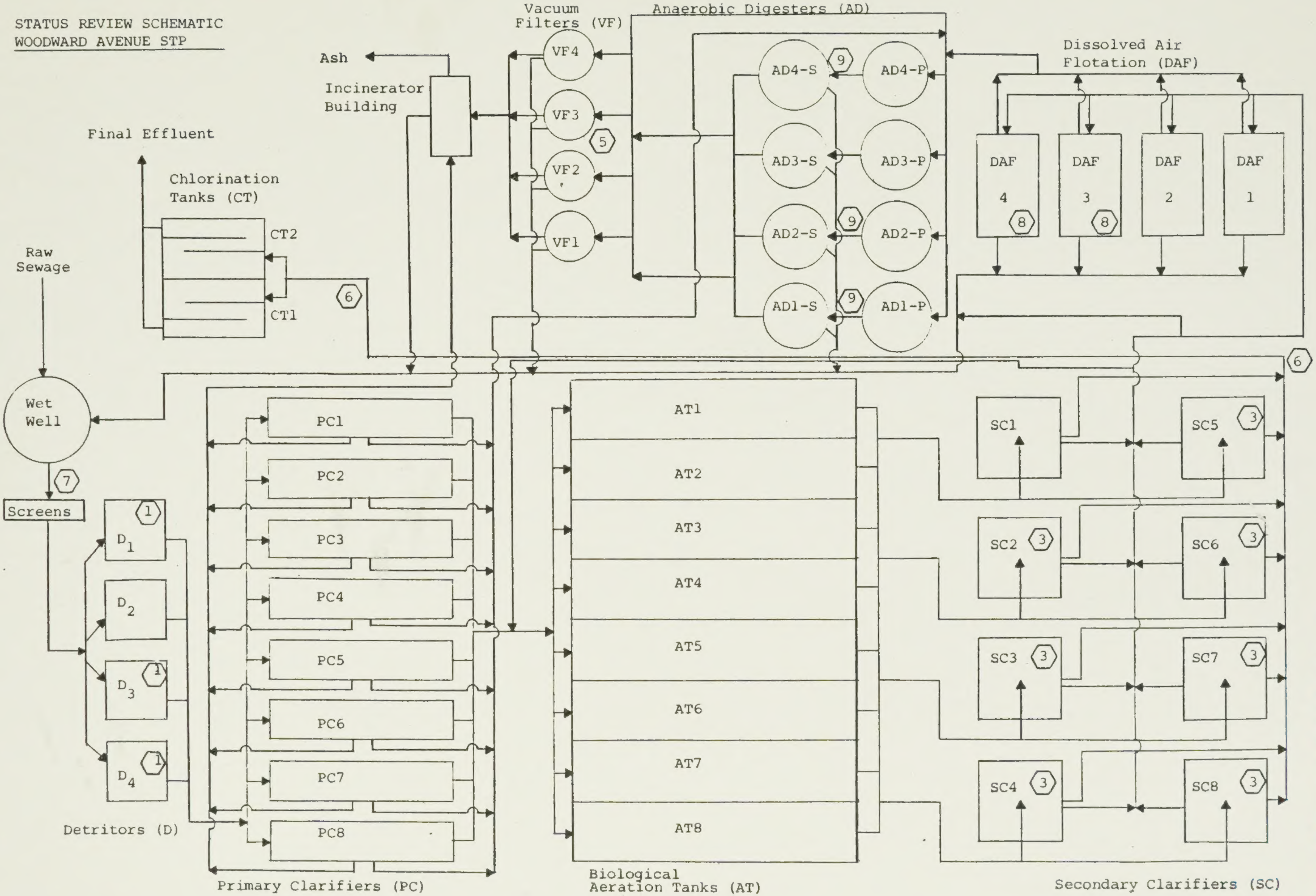
6 Final effluent channel to be cleaned of sludge deposits on bottom

7 Splitter gates in influent headworks need repair and/or replacement

8 Liquid level control system on air dissolving tanks to be replaced before use.

9 Mechanical repairs and cleanout underway but not yet complete.

STATUS REVIEW SCHEMATIC
WOODWARD AVENUE STP



POLLUTECH

HAMILTON PUBLIC LIBRARY
3 2022 21333712 0